1,153,504

PATENT SPECIFICATION

DRAWINGS ATTACHED

1,153,504

Inventor: MICHAEL JOHN SLATER

Date of filing Complete Specification: 19 Sept., 1967.

Application Date: 26 Oct., 1966. No. 48097/66.

Complete Specification Published: 29 May, 1969.

Index at acceptance:—B1 F4G; B1 J(3A3, 6A2C, 6B2, 6B4); B2 H(4, 7)

Int. Cl.:—B 01 f 5/00

COMPLETE SPECIFICATION

Liquid Particulate Solid Contacting Apparatus

We, INTERNATIONAL RESEARCH & DEVELOPMENT COMPANY LIMITED, a British Company, of Fossway, Newcastle-upon-Tyne 6, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to liquid-particulate solid contacting apparatus of the continuous counterflow type. Such apparatus finds application in ion exchange processes, molecular sieve adsorption, leaching of ores, washing of crystals and similar processes.

Typically such apparatus comprises a vertical column through which the particulate solid descends through an upward flow of liquid. In one known arrangement of this type, beds of solid particles are supported on perforated trays which may have simple perforations or be of the bubble-cap type. The liquid can flow upwards through the trays and over the particles which are rendered mobile so that they flow through the bed to the edge of the tray and thence over the edge to fall by gravity through a transfer passage onto a tray below.

To move the particles from tray to tray various methods have been proposed. The upflow of liquid may be sufficient to render the particles sufficiently mobile for flow through the bed and over the edge of the tray to take place. However, this system is unstable since liquid may by-pass the particle beds, flowing instead through the transfer passages. In another arrangement the whole of the fluid flowing upwards through the particle beds is pulsed by external means so as to render the particles more mobile and the operation more stable since by-passing of stages can be reduced, but with such an arrangement, whilst the process is more continuous, the pulses affect not only the beds of particles but also the passages through which the particles fall from one bed to another so that some pulse energy is wasted. In another arrangement, the flow of liquid through the particle bed or beds is reversed intermittently, but this means that continuous counter flow of liquid through the particle beds cannot be achieved.

In all these arrangements there are disadvantages of low solids fluxes or intermittent operation.

According to the present invention liquid-particulate solid contacting apparatus comprises a column containing a plurality of vertically spaced perforated trays for supporting the particulate solid, each tray having an edge portion bounding an opening for the passage of said particulate solid from one tray to a tray below, a retraining wall for particulate solid disposed along said edge portion, and a baffle assembly extending over said opening but spaced from the tray, said baffle assembly having a baffle portion over-lapping said retaining wall in a vertical direction but in spaced relation thereto, means for supplying particulate solid to the top of the column, means for passing a liquid upwards through said column through the trays containing particulate solid and means for supplying a pulsating fluid pressure to the space enclosed by at least the lowermost baffle assembly.

The opening for the passage of particulate solid from one tray to the tray below may be defined between an edge of the tray and a wall of the column or take the form of an opening in the tray itself. Openings in consecutive trays may lie at opposite sides of the column or, in an alternative arrangement, an opening in one tray may lie centrally within the tray with the openings in the tray immediately below being located adjacent a wall or two opposite walls of the column.

The pulsed fluid pressure may be produced by compressed air or other fluid supplied through a rotary valve adapted to induce a pulsating pressure in the air.

In order that the invention may be fully understood it will be described in one form by way of example with reference to the draw-

ings accompanying the Provisional Specification, in which:

Figure 1 is a section through a liquid-particulate solid contacting apparatus in accordance with one embodiment of the invention.

Figure 2 is a section through a rotary valve for inducing pressure pulses in a gas passing therethrough.

Figure 2A is a view on section AA of the valve of Figure 2.

Figure 2B is a view on section BB of the valve of Figure 2.

Referring to Figure 1, liquid-particulate solid contacting apparatus comprises a vertical column 1 typically of circular, or rectangular cross section incorporating a plurality of vertically spaced perforated trays 2—4 for supporting beds 5—7 of particulate solid, the size of the perforations being small enough such that the particulate solid does not fall through, but large enough to allow liquid to flow therethrough without suffering a large pressure drop. The perforations may take the form of simple openings or be in the form of bubble caps.

In the embodiment illustrated an opening for the passage of particulate solid from one tray to the tray below is defined between an edge portion of a tray and a wall of the column. Thus opening 8 for the passage of particulate solid from tray 2 to tray 3 is defined between the edge portion of tray 2 and the wall of column 1. Opening 9 is formed between edge of tray 3 and the opposite wall of the column 1 as shown and opening 10 between edge of tray 4 and the wall of the column 1.

Disposed along each edge portion is a retaining wall which is mainly required to prevent solids flow when pulsing is stopped. Retaining walls 11—13 are associated with trays 2—4 respectively.

Extending over each of the passages 8—10 is a baffle assembly comprising a wall portion 14*a*—16*a*, respectively, and a sloping portion 14*b*—16*b*, respectively. Each baffle assembly has a wall portion which overlaps the retaining wall of the tray with which it is associated in a vertical direction and is in spaced relation thereto as shown. Thus the wall portion 14*a* overlaps the retaining wall 11, the wall portion 15*a* overlaps the retaining wall 12 and so on. As a result of this arrangement each baffle assembly defines a chamber 17, 18 or 19 surrounding an opening in which chambers process liquid having a pulsating motion serves to transfer solids from one tray to the tray below.

Gas, for example compressed air, from rotary valve 20 is introduced through duct 21 to lowermost chamber 19 via control valve 22. The rotary valve 20 can be operated continuously or intermittently if desired to give quiescent intervals between pulses or lower solids flow rates or both effects.

Process liquid for contacting the particulate solid is introduced through inlet 23 and flows upwards in continuous manner through the column passing through the beds of particulate solid on the trays and leaving through outlet 24.

The particulate solid is introduced through inlet 25 into a space 26 by means of a carrier fluid which may be a separate fluid such as air or liquid from another apparatus or the process liquid product itself. The particulate solid is supported by tray 27 which in the form shown is not perforated, but which could be perforated if desired, although this would probably entail excessive mixing of the process liquid and the carrier fluid used to introduce the particulate solid into space 26. If air or process liquid product is used as the carrier fluid no problem is presented by such mixing.

Baffle assembly 28*a* and 28*b* of the same form as the other baffle assemblies is provided around opening 29 at the edge of tray 27 and the solids pass from the tray 27 via chamber 30 in a similar manner to the perforated trays.

Pressure pulses applied to lowermost chamber 19 induces flow in all of the chambers 17—19 and 30 alternatively in the same direction as the process fluid and in the reverse direction. When a pressure pulse induces a current of process liquid to flow counter to the main upward flow, particulate solid is induced with some surrounding process liquid to flow off each tray and over the retaining walls. During this time and also when the induction flow ceases solids drawn over the retaining walls fall into the bed of solids on the tray below. The pulse shape may be such that at the end of each period of induction flow, a short period of relative quiescence allows solids to fall to the tray below and such that the periods of flow in the direction of the process fluid and the reverse direction are different or equal.

The solids flow rate is controlled by the rate and amplitude of the pulsing, the shape of the pulse, the physical dimensions of the passages between the wall portion 14*a*—16*a* of the baffle assemblies and the retaining walls 11—13 and the height of particulate solid on the trays.

Whilst the embodiment described the pulsations are induced by introducing a fluid such as compressed air to the lowermost chamber only, the fluid can be introduced into other chambers if so desired.

The beds of solids may be maintained as bed of moving particles with relatively little motion between particles to avoid back mixing of the solids or as fluidised beds in which mixing of the particles is considerable.

The dimensions of the passages formed between the retaining walls 11—13 and the wall portions 14*a*—16*a* of the baffle assemblied and between the lower edge of the said wall portions and the trays, should preferably be such

that the passages have substantially constant cross-section to avoid the introduction of flow restrictions. The height of the bottom of the wall portions 14*a*—16*a* of the baffle assemblies above the trays should be several times the mean particle diameter. In a typical case the height would be of the order of at least six times the mean particle diameter. The height mentioned would normally be less than the height of the bed as shown. The sloping portions 14*b*—16*b* of the baffle assemblies are typically in the range 30°—70° to the horizontal.

If a separate carrier fluid is used to introduce the particulate solid, this fluid can be removed via outlet 31.

The solids flow downwards against the flow of process liquid and collect in reservoir 32 at the bottom of the column and are withdrawn as a concentrated slurry from outlet 33. The reservoir need not be of the shape shown. The baffle 34 allows unhindered settling of solids in the reservoir 32. The solids may simply collect in a suitable space below the liquid feed point 23.

During initial filling of the column 1 the chambers, 17—19 and 30 must be vented to allow air to escape. Small holes in the sloping portions 14*b*—16*b* and 28*b* at the highest points of the chambers 17—19 and 30 can be provided and will not significantly affect the pulse action, or vents to atmosphere can be used.

Referring to Figures 2, 2*a* and 2*b* the rotary valve 20 comprises a cylindrical body member 35 on the surface of which are several longitudinal slots 36 of uniformly varying width. The member 35 rotates, at a speed which can be varied, within a stationary block 37. A hole 38 passes radially through the block and the rotating member 35 alternatively opens and closes the hole at its inner end. Compressed air is fed to pipe 39 and passes via pipe 21 to the column 1. The pressure of the air in the chamber 19 is cyclically varied by the action of member 35 which allows compressed air to vent through the hole 38 and the slots 36 at a speed determined by the speed of rotation of member 35 and on the relative position of the member 35 relative to the block 37 and on the air pressure.

Whilst the use of compressed air has been mentioned other fluids can be used including the process liquid itself to produce the necessary pulses. The form of valve shown is given by way of example and other pulse producing devices can be used.

By applying the pulses to the process liquid in a small chamber at say the bottom of the column a continuous flow of process liquid can be maintained in the column and the pulse energy required is more effectively used to induce solids flow than that required in systems where pulse are induced in the whole of the process liquid. The pulse action affects each bed of solids to substantially the same degree and produces substantially equal flow of solids from each bed. The pulse action is not primarily required to render the solids mobile but to enhance solids transfer from tray to tray.

The system is inherently stable as a fall in a bed height on a particular tray reduces the flow of solids from the tray and vice-versa. The column is therefore easily filled or emptied of solids.

As the flow of solids is not dependent solely on gravity effects the ration of the volume flow of solids to flow of processing liquid can approach and in some cases exceed unity at liquid flow rates sufficient to fluidise the solids.

If more than one column of the kind described is used the net carry over of process liquid from one column to the next by the solids is reduced compared with conventional arrangements because a high degree of separation of solids and carrier liquid is effected using the method of pulsing to induce solids flow from a chamber such as the chamber 26.

WHAT WE CLAIM IS :—

1. Liquid-particulate solid contacting apparatus comprising a column containing a plurality of vertically spaced perforated trays for supporting the particulate solid, each tray having an edge portion bounding an opening for the passage of said particulate solid from one tray to a tray below, a retaining wall for particulate solid disposed along said edge portion, and a baffle assembly extending over said opening but spaced from the tray, said baffle assembly having a baffle portion overlapping said retaining wall in a vertical direction but in spaced relation thereto, means for supplying particulate solid to the top of the column, means for passing a liquid upwards through said column through the trays containing particulate solid and means for supplying a pulsating fluid pressure to the space enclosed by at least the lowermost baffle assembly.

2. Apparatus as claimed in claim 1 in which the opening for the passage of the particulate solid from one tray to the tray below is bounded by the edge portion of the tray and a side wall of the column.

3. Apparatus as claimed in claim 2 in which the openings in consecutive trays lie at opposite sides of the column.

4. Apparatus as claimed in any of the preceding claims in which the means for supplying particulate solid to the top of the column comprise an imperforate top tray having an edge portion bounding an opening for the downward passage of the particulate solid, a retaining wall disposed along the edge portion, and a baffle assembly extending over the opening and spaced from the tray, and a chamber above the imperforate tray having an inlet for liquid carrying the particulate solid and an outlet for the carrier liquid.

5. Apparatus as claimed in any of the preceding claims including a partition below the

lowermost tray dividing a chamber to which the liquid is supplied from a chamber into which the particulate solid falls from the opening in the tray.

6. Apparatus as claimed in any of the preceding claims in which the means for supplying a pulsating fluid pressure comprises a conduit for the supply of air under pressure and a vent for said conduit having a rotary valve which periodically opens and closes said vent.

7. Apparatus as claimed in claim 6 in which the rotary valve has a rotary drum with channels in its periphery which increase progressively in width along the length of the drum, and a non-rotating block within which the drum rotates, the drum being axially adjustable with respect to the block to vary the time for which the vent is open.

8. Apparatus for contacting a liquid and a particulate solid substantially as described with reference to Fig. 1.

9. Apparatus as claimed in claim 8 including a rotary valve substantially as described with reference to Figs. 2, 2A and 2B.

REDDIE & GROSE,
Agents for the Applicants,
6 Bream's Buildings,
London, E.C.4.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1969.
Published by the Patent Office, 25 Southampton Buildings, London, W.C.2, from which copies may be obtained.

1153504 PROVISIONAL SPECIFICATION
2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

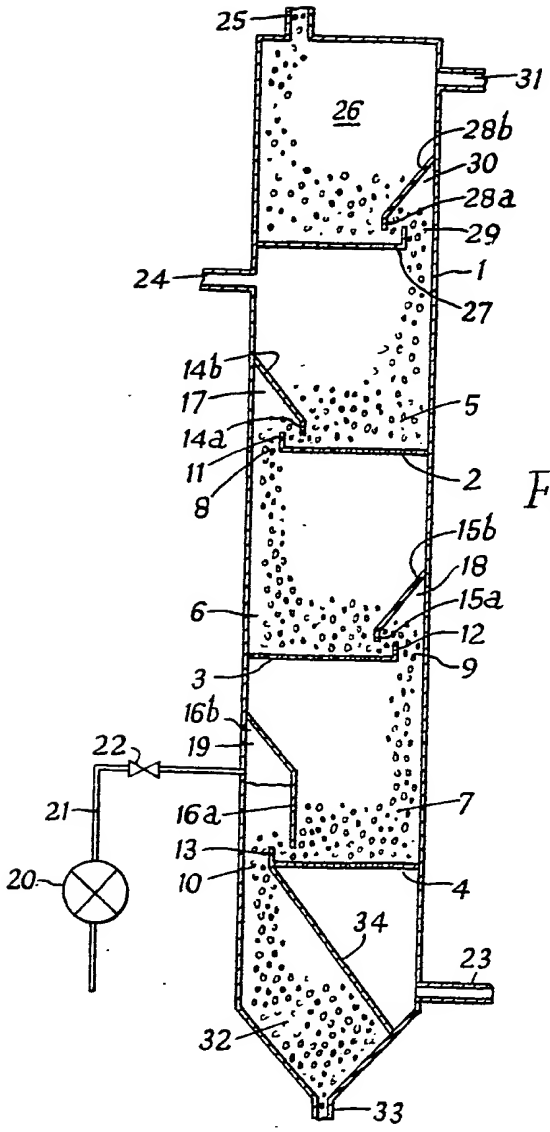

Fig. 1.

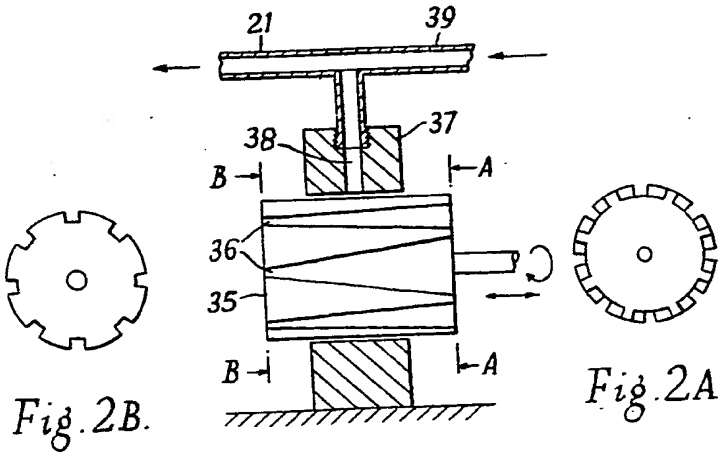

Fig.2B. Fig.2A.

Fig.2.